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Improved Martingale Betting System for Intraday Trading in Index Futures

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ABSTRACT

Martingale betting method originated from roulette, the concept is that if this bet is lost, the next bet will be doubled until a certain win, then the bet will be returned to the original bet amount. Theoretically, under a fair game, this method will definitely win, but in reality, limited by the amount of funds, unfair games (super martingale) and other factors, the Martingale betting method cannot be successful. In this study, we propose an innovative capital management method – the Improved Martingale Betting System (IMBS), which is to change the traditional martingale betting method and add a stop-loss mechanism. The test results of applying it to intraday trading of three major index futures in the United States, Germany and Taiwan show that the IMBS has a significant better performance compared with the transaction without fund management or the transaction using the traditional martingale betting method. Therefore, this paper shows that the improved martingale betting method has extremely high application value in the intraday trading of index futures.

Key words and phrases: Martingale betting system, Equity Index Futures, Intraday Trading, Improved martingale betting system.

JEL classification: G13.

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1. Introduction

In probability theory and applied stochastic processes literature, almost all researchers proved that in a fair random environment any naive betting strategy cannot gain positive profits. The standard martingale betting method is more probably leading to bankruptcy with a limited amount of initial capital. However, there are different views on whether stock price movement is a pure random walk as often being modeled as a geometric Brownian motion, and there are some traders have achieved good performance in reality.

A trading strategy in general can be divided into two parts: an entry and exit decision and a fund management policy. In order to test the profitability, this research focuses on the role of fund management policy and proposes a new betting strategy, the so-called Improved Martingale Betting System (IMBS), in which the stop loss magnitude is set and the unlimited number of double betting of the traditional Martingale Betting System (MBS) is modified. We will apply the IMBS to three equity index futures including TAIEX Futures, e-mini S&P500 Futures and DAX Futures contracts as our samples to test the new trading strategy in intraday trading. The results show that the proposed IMBS has a significant improvement in mean return rate as compared to the Equal Weight Betting System (EWBS), and the standard MBS without stop loss mechanism has the lowest mean return rate and the highest probability of bankruptcy. These results can be useful for actual security trading and are consistent to the existing literature. The rest of the paper is arranged as follows: Section 2 is the literature review, in 2.1 we will discuss some previous researches concerning trading policy, emphasizing the empirical investigation of actual application of investment rules. In 2.2 we present some popular betting system including standard Martingale Betting System and Equal Weight Betting System. In the Subsection 2.3 we introduce our new method: The Improved Martingale Betting System. Section 3 is the research method and Section 4 is the empirical results. Finally, Section 5 is the conclusion of the paper.

2. Previous Researches

2.1 Literature Review and Betting systems

In this subsection we will first define the terminology regarding to betting systems and gambling policy and then present the empirical study of the most popular application of gambling systems applied to the actual investment practice.

A gambling system is a sequence of an independent and identical binary random variables with probability p and $q\,(=1-p)$, the gambler bets at unit stake and he gains one dollar if one outcome appears (using coin tossing as an example, if the head (H) appears) and he loses one dollar if the tail (T) appears. This game goes on indefinitely. If the player follows some rules for betting head or tail then we call the system a selection system. Two commonly seen systems are momentum strategy and contraction strategy, for example, a momentum strategy is as follows: if the sequence of outcomes is HHH (TTT), then he bets H (T) for the next game, on the other hand, the contraction strategy is: if HHH (TTT) appear, he bets T (H) for the next game. (For detail exposition, see Billingsley, 1986; Feller, 1971). If the player bets different amounts depending on some previous information, then we have a betting system, furthermore, if the player has some target amount of wealth starting from an amount of initial capital then we call the system is a gambling policy (for example, the bold play or timid play). If the system has some form of stopping rule, the system is called an improved betting system, which is proposed for the first time in this paper.

In what follows of this subsection we will focus on the discussion of betting system including martingale betting system and Kelly formula applied to intraday trading in various financial markets and in the next subsection we will propose the Improved Martingale Betting system.

Suppose that a betting game has a winning probability p, a loss probability $q\,(=1-p)$, the winning payoff is w, the loss is l, and the random variable X_k defined as the outcome of the k^{th} bet, a winning bet is recorded as $X_k = 1$, and a losing bet is recorded as $X_k = -1$, i.e., X_k is the k^{th} game profit per unit stake, R_k is the profit of betting B_k, and CR_k is the cumulative profit up to k^{th} game. Then the expected profit of the k^{th} unit bet $E[X_k]$ will be:

$$E[X_k] = (p \times w - q \times l) = l\left[\left(\frac{w}{l}+1\right)p-1\right] \tag{1}$$

Assuming that the input amount of the k^{th} bet is B_k $(k = 1, 2, ..., m)$, the profit or loss of k^{th} bet will be: $R_k = X_k B_k$. After m rounds of consecutive betting, the sum of profit and loss R_k will be: $CR_m = \sum_{k=1}^{m} X_k B_k$, where X_k and B_k are independent and thus the expected value of CR_m will be:

$$E\left[CR_m\right] = \sum_{k=1}^{m} E\left[X_k B_k\right] = \sum_{k=1}^{m} E\left[X_k\right] E\left[B_k\right] = \sum_{k=1}^{m} l\left[\left(\frac{w}{l}+1\right)p-1\right] E\left[B_k\right] .$$

In a fair random game, it is usually $w = l$ and $p = 0.5$, but in the actual market trading, w, l and p are not the case. The expected value of CR_m shows that if $\left(\frac{w}{l}+1\right)p-1 > 0$, then the expected value of the total profit and loss of trading would be positive. The values of w, l and p are determined by the given game, what we can do is to consider fund management policy, therefore we consider some of the well-known methods of betting capital B_k for each bet and assume that the initial capital is V_0.

(A) Martingale Betting System

The MBS method means that if this round of gambling is lost, the bet of next round will be doubled, and if a losing streak is repeated until a winning appears and then the bet starts anew of 1 dollar. The betting amount can be expressed as:

$$B_k = \begin{cases} 2 \times B_{k-1}, & if \;\; X_{k-1} = -1\,, \\ 1, & if \;\; X_{k-1} = +1\,. \end{cases}$$

Therefore, the change of the bet amount B_k can be expressed as:

$$\begin{cases} B_k > B_{k-1}, & if \;\; R_{k-1} < R_{k-2}\,, \\ B_k < B_{k-1}, & if \;\; R_{k-1} > R_{k-2}\,. \end{cases}$$

Under the assumptions of $w = 1$, $l = -1$, this method can earn infinite amount of money, because he can bet until winning and start anew:

$$\begin{aligned} CR_{m+1} &= -1 - 2^1 - 2^2 - ... - 2^{m-1} + 2^m \\ &= -\left(1 + 2^1 + 2^2 + ... + 2^{m-1}\right) + 2^m = 1 \end{aligned}$$

To actually implement this strategy, it requires that the players have infinite amount of capital and time, but this is impossible in practice.

(B) Kelly Formula

Regarding the coin tossing game, Kelly (1956) proposed Kelly Criterion to define the limit of capital growth rate G of the gambler's m^{th} game as:

$$G = \lim_{m \to \infty} \frac{1}{m} \log_2 \left(\frac{V_m}{V_o} \right) . \tag{2}$$

Here V_0 is the gambler's initial capital and V_m is the total capital after m bets. Since Kelly Criterion assumes the winning rate $p > \frac{1}{2}$, the gambler only considers the betting ratio f^*. After n bets, the total capital can be expressed as:

$$V_m = (1 + f^*)^w (1 - f^*)^l V_0 \, ,$$

where w is the number of games won by the bet, l is the number of games lost by the bet, and $w + l = m$. To maximize the value of G, he showed that the gambler will get the largest V_m via betting at a ratio of $f^* = 2p - 1$. Later, Thorp and Kassouf (1967) introduced the concept of odds b, the ratio of the amount to win divided by the amount to lose, that is $b = \frac{w}{l}$ in (1) and proposed a revised Kelly Formula to be used in the stock market:

$$f^* = p - \frac{q}{b} = \frac{p(b+1) - 1}{b} \, . \tag{3}$$

Following Kelly Formula, the k^{th} bet amount B_k can be expressed as: $B_k = f^* \times V_{k-1}$, and the capital after the k^{th} bet is the sum of previous capital and the gain from k^{th} bet: $V_k = V_{k-1} + R_k$. Therefore, the change of the bet amount B_k can be expressed as:

$$\begin{cases} B_k > B_{k-1}, & if \ R_{k-1} > 0 \, , \\ B_k < B_{k-1}, & if \ R_{k-1} < 0 \, . \end{cases}$$

There are some previous researches applying Kelly formula in a generalized framework, e.g. Byrnes and Barnett (2018). For the empirical test of the formula, Hu (2019) applied the formula to the investment in Taiwan stock market under the framework of LSTM (Long Short-Term Memory). He found that the Kelly formula cannot effectively increase the return of the portfolio, but rather it can help reduce the risk level of the portfolio. Ohlsson and Markusson (2017) applied the formula to test its effect in Swedish stock market and found similar results. Wu and Chung (2018) applied the formula to construct option portfolio and obtain a satisfactory result.

(C) Equal Weight Betting System, EWBS

In this system, $B_k = a \times V_0$, $0 < a \leq 1$, where a is the betting ratio. In each bet a is a fixed value that does not change with k, which is also the most commonly used fund management policy for actual trading strategy. We will also apply this betting system in our empirical test and compared it with other methods.

2.2 IMBS —Improved Martingale Betting System

This approach is proposed in this research, the so-called Improved Martingale Betting System (IMBS). In view of the excessive increase in MBS's betting amount and the consequent sharp increase in risk or it needs unlimited amount of capital, which is unpractical in the real world, we hence design this method of betting. IMBS means that if this round of gambling is lost, the next round betting will be a times of the amount of this round. If one loses consecutively, it will be multiplied until winning the game. Same as Kelly Formula, the capital after the k^{th} bet is the capital of the $(k-1)^{\text{th}}$ plus the gain of the k^{th} bet, however, the number of multiples is limited to m folds and the betting amount can be expressed as:

$$B_k = \begin{cases} \min\{a \times B_{k-1},\, a^n \times B_1\}, & if\ X_{k-1} = -1\,, \\ 1, & if\ X_{k-1} = +1\,. \end{cases} \tag{4}$$

The change of the betting amount B_k is the same as MBS and can be expressed as:

$$\begin{cases} B_k > B_{k-1}, & if\ R_{k-1} < R_{k-2}\,, \\ B_k < B_{k-1}, & if\ R_{k-1} > R_{k-2}\,. \end{cases}$$

As shown in the B_k expression, when the B_k exceeds the upper bound $a^n \times B_1$ the betting amount remains at the same level. It can be seen from the above expressions that MBS, IMBS and Kelly Formula all aim to increase the total profit by increasing or decreasing the bet, but the mechanism of MBS, IMBS vs. Kelly Formula are in opposite directions, for the first two approaches the bet will decrease to the initial level (B_1) when winning the game, but for the Kelly Formula the bet will increase when winning the game due to relative risk becomes smaller, therefore Kelly Formula is more like momentum strategy.

3. Research Method

3.1 Research Data

In this research we take three equity index futures as our samples: Taiwan Stock Exchange Capitalization Weighted Stock Index futures (TX), E-mini S&P500 Futures (ES), DAX index futures (DAX), and collect their historical data on the near month contracts from 2001 to 2020. We use 5-minutes data including the opening, closing, lowest and highest prices. When determining go into the market, the opening price of 2nd five-minute data will be the entering price, and if there is no stop loss the position will be closed at the closing price of the last five-minute data. All tests in this paper are intraday trading, started from 8:45am to 13:45pm, therefore, all transactions are closed at the end of day trading time. One important reason for using five-minute data is to simulate the situation of stop loss in intraday trading because sometimes it seems to be profitable on the daily data, but stop loss happened within the day.

3.2 EWBS Test

Before the market begins to trade, we draw a random number μ between 0.00 and 1.00 to decide to go long (if $\mu > 0.50$) or short (if $\mu < 0.50$) or not enter into the market (if $\mu = 0.50$). In terms of discrete distribution, the chance of $\mu = 0.50$ occurring is about 1/101. This is in line with the original intention of the design: to keep the number of non-entries as low as possible. Except $\mu = 0.50$, we execute the transaction at the opening price of the second five minute price and exit all contracts at the day closing price. EWBS means each bet amount equals to the capital. Considering that futures are traded on margin, the bet amount should be the contract market value rather than the margin amount, and we denote that the capital as V, the trading entry price as S, point value of the contract as PV, then the volume of order CN will be:

$$CN_k = \frac{V_k}{S_k \times PV}\,. \tag{5}$$

Profits or losses will be accumulated into the capital, which becomes the basis for calculating the capital of the next bet: $V_k = V_{k-1} + R_{k-1}$. We will conduct 100,000 rounds of EWBS test for each instrument from 2001 to 2020 and each round has nearly 5,000 random bets.

3.3 Stop Loss

Theoretically the cumulative profit (or loss) for a pure random entry in intraday trading will be a martingale; otherwise there will be arbitrage opportunities. By adding stop loss mechanism, we can control the loss amount and hope to change the process into non-martingale. We calculate the historical average distance θ for the difference between the daily opening price and closing price of each futures contract, and take 0.25 times, 0.5 times, 0.75 times, and 1 time as the daily stop loss rate $SL_F : SL_F = \theta_F \times (0.25, 0.5, 0.75, 1)$, where F denotes TX, ES, or DAX.

The average distance between daily opening price and closing price of TX is 0.76%, 0.83% of ES, and 0.90% of DAX respectively. The trading entry conditions and mechanisms of EWBS with SL are like EWBS without SL, and the exit condition is to hold until the close of the market unless it hits the stop loss price. We will conduct 100,000 rounds of tests for four settings of SL rates with EWBS, totally 400,000 rounds for each futures contract.

3.4 IMBS and MBS

We set the IMBS parameters $\boldsymbol{a} = (1.25, 1.5, 1.75, 2.0)$, $\boldsymbol{n} = (1, 3, 5)$, and $\boldsymbol{SL} = (0, 0.25\theta, 0.5\theta, 0.75\theta, 1\theta)$, here 0 means no SL, EWBS equals to IMBS ($a = 1, n = 1$), and MBS is as IMBS ($a = 2, n = 1, 3, 5$). Compared with traditional martingale betting system (MBS), IMBS has three modifications. The first is the stop loss mechanism, and the second one is the difference in the multiple of each bet. MBS increases the bet in multiples of 2, and that will be $2^1, 2^2, 2^3, ..., 2^n$. But IMBS will increase the bet in multiples of a from $a^1, a^2, 2^3, ...,$ to a^n, and a could be 1.25, 1.5,..., or 2. In this paper we also have tested several settings of a. Thirdly, because of the limitation of futures trading leverage, we also limits the total amount of a^n such that $a^n \leq 20$. The reason for limiting $a^n \leq 20$ is that the margin required for equity index futures trading is

Table 1: Bet amount of each method in a losing streak.

	EWBS	**Original MBS**	**IMBS (a=2)**	**IMBS (a=1.5)**	**IMBS (a=1.25)**
First Bet	1	$2^0 = 1$	$2^0 = 1$	$a^0 = 1$	$a^0 = 1$
Loss	1	$2^1 = 2$	$2^1 = 2$	$a^1 = 1.5$	$a^1 = 1.25$
Loss	1	$2^2 = 4$	$2^2 = 4$	$a^2 = 2.25$	$a^2 \cong 1.56$
Loss	1	$2^3 = 8$	$2^3 = 8$	$a^3 \cong 3.38$	$a^3 \cong 1.95$
Loss	1	$2^4 = 16$	$2^4 = 16$	$a^4 \cong 5.06$	$a^4 \cong 2.44$
Loss	1	$2^5 = 32$	$\min(2^5, 20) = 20$	$a^5 \cong 7.59$	$a^5 \cong 3.05$
Loss	1	$2^6 = 64$	$\min(2^6, 20) = 20$	$a^6 \cong 11.39$	$a^6 \cong 3.81$
Loss	1	$2^7 = 128$	$\min(2^7, 20) = 20$	$a^7 \cong 17.09$	$a^7 \cong 4.77$
Loss	1	$2^8 = 256$	$\min(2^8, 20) = 20$	$\min(a^8, 20) = 20$	$a^8 \cong 5.96$
Loss	1	$2^9 = 512$	$\min(2^9, 20) = 20$	$\min(a^9, 20) = 20$	$a^9 \cong 7.45$
Win	1	1	1	1	1

normally 5% of the contract market value, which is a leverage level of 20 times, hence even if MBS doubles the bet at 2^n, it is impossible to trade more than 20 times of the market value of the contract V. From this setup, we can see that the popular trading strategy EWBS and the standard gaming method MBS are all special cases of our innovative scheme IMBS. We will conduct a test of 100,000 rounds of various combinations of the parameters a, n, and SL, totally six million rounds for each equity futures contract. Table 1 shows that all methods encountered a losing streak and the bet amount.

4. Empirical Results

4.1 EWBS without Stop Loss

Table 2 shows that the result of each of the three futures contract conducted with 100,000 rounds of random entry tests by setting EWBS without SL from 2001 to 2020. The mean returns of the three contracts were all negative, and none of the test results causes bankruptcy.

Table 2: Returns of EWBS.

Symbol	***SL***	***a***	***n***	**Mean Return**	**Standard Deviation (σ)**	**Mean Broken Rate**
TX	non	1	1	-0.09	0.37	0.00%
ES	non	1	1	-0.41	0.27	0.00%
DAX	non	1	1	-0.26	0.47	0.00%

4.2 EWBS with Stop Loss

Consider the one-tailed paired t-test with the null hypothesis $\mathrm{H}_0 : \mu_{EWBS,SL} = \mu_{EWBS}$ against the alternative hypothesis $\mathrm{H}_1 : \mu_{EWBS} < \mu_{EWBS,SL}$ for most cases except for the cases of ES with 0.5θ, where $\mu_{EWBS,SL}$ denotes the expected return of the EWBS with SL. The hypotheses for the above excluded case is $\mathrm{H}_0 : \mu_{EWBS,SL} = \mu_{EWBS}$ versus $\mathrm{H}_1 : \mu_{EWBS,SL} < \mu_{EWBS}$. Table 3 shows the results of three instruments conducted with 400,000 rounds of random entry tests by setting EWBS with four levels of SL from 2001 to 2020. It shows that under most levels of SL setting, EWBS with SL have better mean return than those of EWBS without SL, and none of the tests resulting bankruptcy.

The significance tests here are compared with EWBS and most of them are extremely significant ($p < 0.001$), marked as $***$, if it is moderately significant ($p < 0.01$), marked as $**$, and if it is significant ($p < 0.05$) then marked as $*$. There is one setting ($SL = 0.5\theta$) in ES that yield insignificant results. It seems that setting an inappropriately small value for stop loss will have detrimental effect on the return in ES, and it looks like that setting 1θ for stop loss is more appropriate for all three instruments.

In Figure 1, it shows that compared to the results of EWBS without SL, the resulting distributions of EWBS with $SL = 1\theta$ are obviously skewed to the right, and the Stop Loss function seems to have excellent results in TX.

The Stop Loss function improves a little in ES and DAX but seems not that good as in TX shown by Figure 2 and Figure 3.

Table 3: Returns of EWBS with Stop Loss.

Symbol	SL	a	n	**Mean Return**	**Standard Deviation (σ)**	**Mean Broken Rate**	**t-statistics ($\mathrm{H}_1: \mu_{noSL} < \mu_{SL}$)**	**t-statistics ($\mathrm{H}_1: \mu_{noSL} > \mu_{SL}$)**
TX	1θ	1	1	0.21	0.34	0.00%	-194.40^{***}	
	0.75θ	1	1	0.12	0.28	0.00%	-143.61^{***}	
	0.5θ	1	1	0.10	0.24	0.00%	-143.65^{***}	
	0.25θ	1	1	-0.01	0.15	0.00%	-69.05^{***}	
ES	1θ	1	1	-0.39	0.21	0.00%	-12.02^{***}	
	0.75θ	1	1	-0.40	0.18	0.00%	-8.36^{***}	
	0.5θ	1	1	-0.44	0.14	0.00%		28.77^{***}
	0.25θ	1	1	-0.39	0.11	0.00%	-16.04^{***}	
DAX	1θ	1	1	0.30	0.56	0.00%	-242.81^{***}	
	0.75θ	1	1	0.18	0.43	0.00%	-217.87^{***}	
	0.5θ	1	1	0.11	0.34	0.00%	-202.50^{***}	
	0.25θ	1	1	0.11	0.24	0.00%	-224.30^{***}	

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

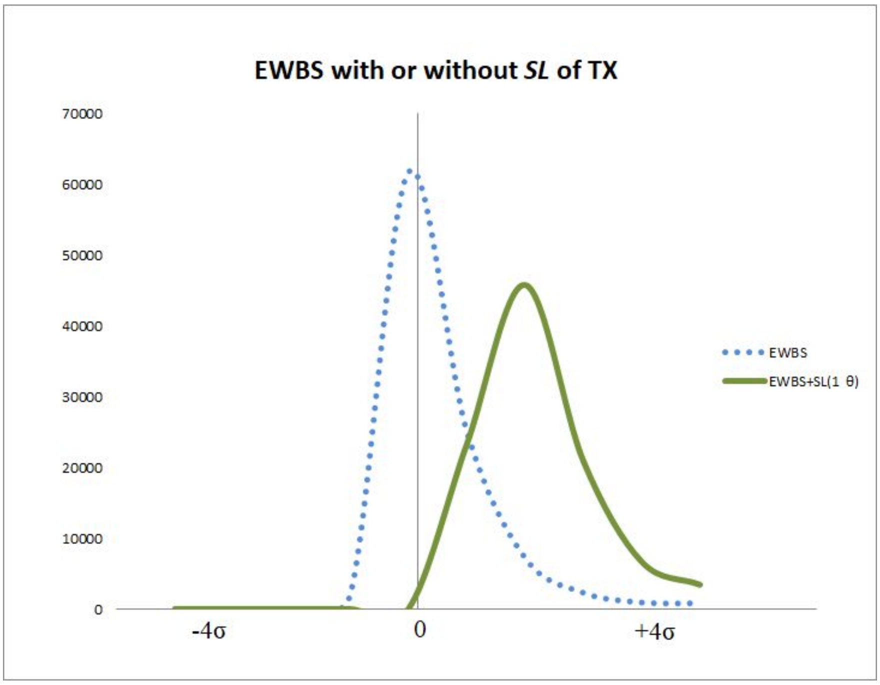

Figure 1: EWBS with or without SL of TX.

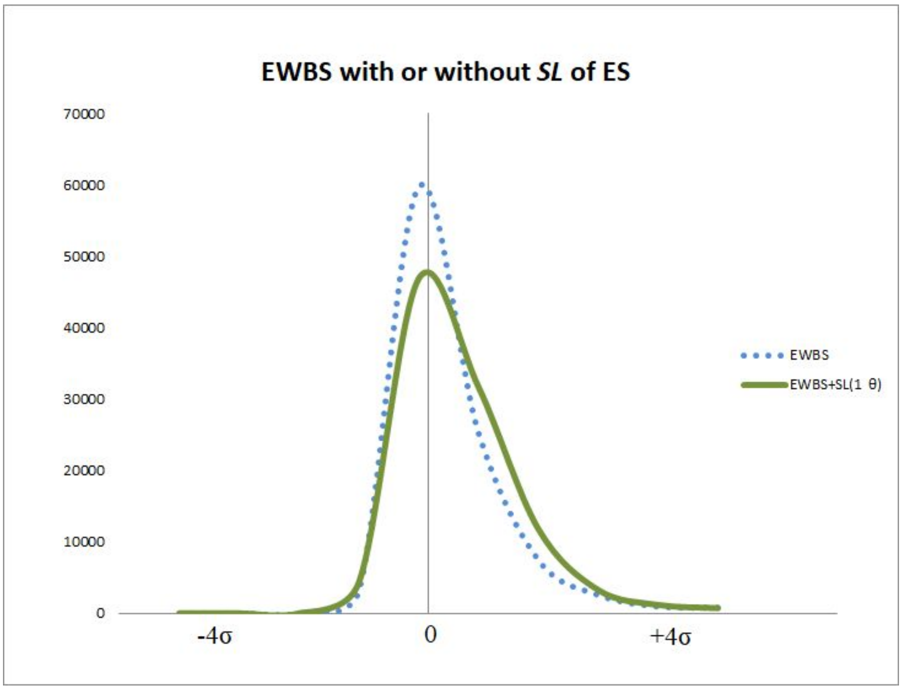

Figure 2: EWBS with or without SL of ES.

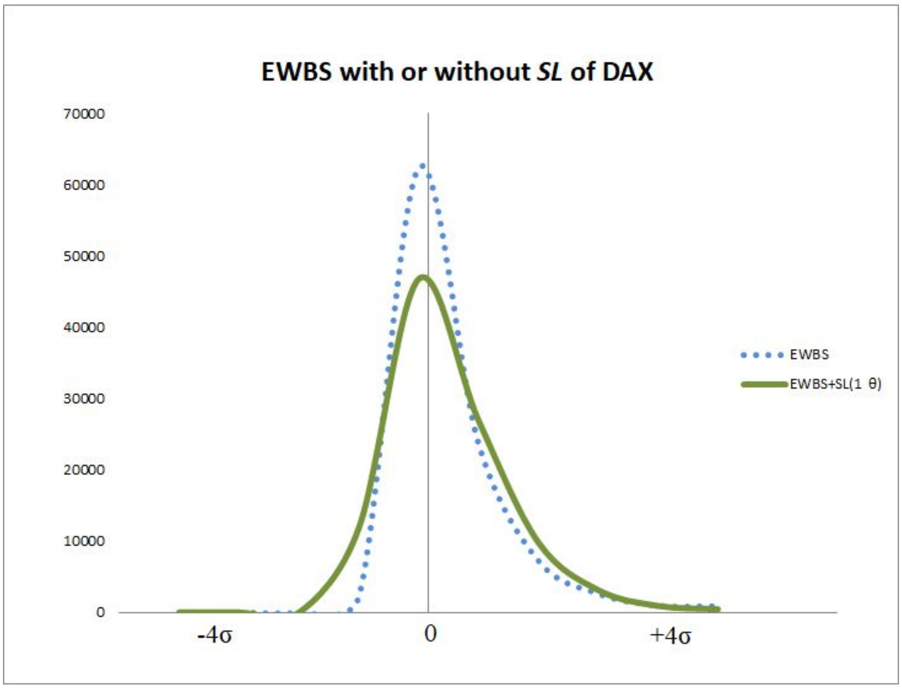

Figure 3: EWBS with or without SL of DAX.

Table 4: Returns of TX under IMBS without stop loss.

SL_{TX}	a	n	Mean Return	Mean Broken Rate	Standard Deviation (σ)	t-statistics ($H_1 : \mu_{EWBS} < \mu_{IMBS}$)	t-statistics ($H_1 : \mu_{EWBS} > \mu_{IMBS}$)
non	1.25	1	-0.06	0.00%	0.91	-4.01^{***}	
non	1.25	3	0.02	0.00%	1.14	-9.88^{***}	
non	1.25	5	0.07	0.00%	1.31	-12.77^{***}	
non	1.5	1	0.00	0.00%	1.13	-8.53^{***}	
non	1.5	3	0.23	0.00%	2.05	-15.68^{***}	
non	1.5	5	0.43	0.00%	3.10	-17.03^{***}	
non	1.75	1	0.03	0.00%	1.44	-8.80^{***}	
non	1.75	3	0.58	0.00%	5.74	-11.75^{***}	
non	1.75	5	1.50	10.38%	43.64	-3.65^{***}	
non	2	1	0.12	0.00%	1.94	-11.16^{***}	
non	2	3	0.78	0.00%	13.77	-6.33^{***}	
non	2	5	1.65	15.93%	41.35	-4.21^{***}	

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

4.3 IMBS without Stop Loss

Consider the one-tailed two sample t-test with the null hypothesis $H_0 : \mu_{IMBS} = \mu_{EWBS}$ against the alternative hypothesis $H_1 : \mu_{EWBS} < \mu_{IMBS}$ except for those cases which t-statistics in Table 4 to Table 6 are close to zero or even positive, and the alternative hypothesis for those excluded cases: $H_1 : \mu_{IMBS} < \mu_{EWBS}$. Table 4 to Table 6 show the results of each of the three instruments conducted with 1,200,000 rounds of random entry tests by setting IMBS without SL and four different levels of betting multiples a and three levels of time limit n from 2001 to 2020.

It can be seen from the tables that the results of IMBS without SL are mostly negative except in TX. As mentioned before, MBS's setting is identical to IMBS a^n with $a = 2$. Under the leverage limitation $a^n \leq 20$, MBS here will be equivalent to the IMBS with setting $a = 2$, $n = 5$. And the result shows that other settings of IMBS without SL are better than MBS's setting without SL whether the mean return value is negative or even turning the return from negative to positive.

The increase of multiplier n seems to have good results in TX, but unlimited normal martingale multiplying function ($a = 2$, $n = 5$) turns result to negative and has 15.93% of tests bankrupted. The IMBS setting with $a = 2$ and $n = 3$ has the best mean return and none of tests is broken.

Table 5: Returns of ES under IMBS without stop loss.

SL_{ES}	a	n	Mean Return	Mean Broken Rate	Standard Deviation (σ)	t-statistics ($H_1 : \mu_{EWBS} < \mu_{IMBS}$)	t-statistics ($H_1 : \mu_{EWBS} > \mu_{IMBS}$)
non	1.25	1	-0.25	0.00%	0.71	-22.20^{***}	
non	1.25	3	-0.27	0.00%	0.85	-16.30^{***}	
non	1.25	5	-0.30	0.00%	0.86	-12.67^{***}	
non	1.5	1	-0.25	0.00%	0.85	-18.37^{***}	
non	1.5	3	-0.30	0.00%	1.40	-7.35^{***}	
non	1.5	5	-0.36	0.00%	2.01	-2.49^{***}	
non	1.75	1	-0.26	0.00%	0.9	-15.98^{***}	
non	1.75	3	-0.38	0.00%	2.11	-1.32	-1.32
non	1.75	5	-0.46	30.23%	5.72	0.85	0.85
non	2	1	-0.26	0.00%	1.23	-11.89^{***}	
non	2	3	-0.32	0.14%	7.78	-1.10	-1.10
non	2	5	-0.50	40.81%	8.58	1.10	1.10

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

Table 6: Returns of DAX under IMBS without stop loss.

SL_{DAX}	a	n	Mean Return	Mean Broken Rate	Standard Deviation (σ)	t-statistics ($H_1 : \mu_{EWBS} < \mu_{IMBS}$)	t-statistics ($H_1 : \mu_{EWBS} > \mu_{IMBS}$)
non	1.25	1	-0.35	0.00%	0.63		13.91^{***}
non	1.25	3	-0.40	0.00%	0.69		19.40^{***}
non	1.25	5	-0.41	0.00%	0.70		21.49^{***}
non	1.5	1	-0.36	0.00%	0.74		13.25^{***}
non	1.5	3	-0.46	0.00%	0.98		19.80^{***}
non	1.5	5	-0.53	0.00%	1.62		16.62^{***}
non	1.75	1	-0.39	0.00%	0.78		16.75^{***}
non	1.75	3	-0.58	0.00%	2.08		15.27^{***}
non	1.75	5	-0.69	19.58%	2.86		14.92^{***}
non	2	1	-0.41	0.00%	0.89		16.95^{***}
non	2	3	-0.69	0.11%	3.36		12.08^{***}
non	2	5	-0.80	35.68%	5.94		9.17^{***}

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

The MBS without SL in ES still shows the worst result and has 40.81% of tests bankrupted. The IMBS setting with $a = 1.25$ and $n = 1$ has the best mean return and none of tests is broken.

Different from TX and ES, the results of IMBS without SL are all significantly worse than EWBS without SL. And similarly, the MBS without SL in DAX also has the worst result and 35.68% of tests are bankrupted. The IMBS setting with $a = 1.25$ and $n = 1$ has the best mean return and none of tests is broken. This also shows that adding leverage without a stop loss mechanism may incur additional risk.

From Figures 4 to 6, we show the results of EMBS, IMBS, and MBS all without SL in each instrument. For IMBS, we chose the highest mean return value without broken as the distribution to present. We can see that MBS without SL has the worst results in all three instruments, and IMBS without SL has the better result, especially in ES (Figure 5).

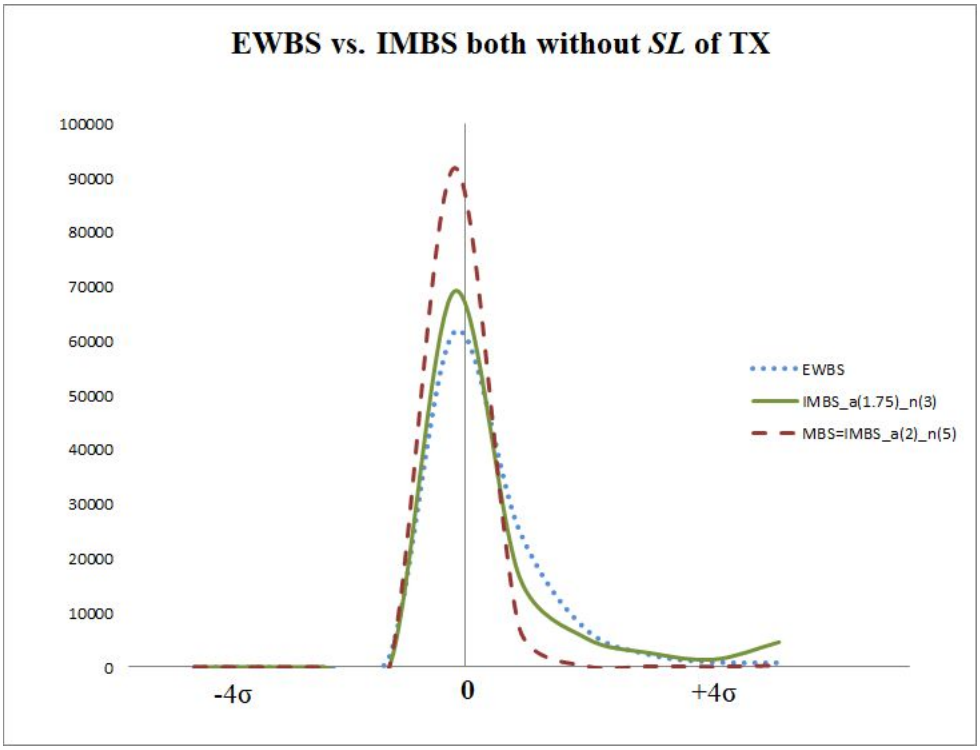

Figure 4: EWBS and IMBS both without SL of TX.

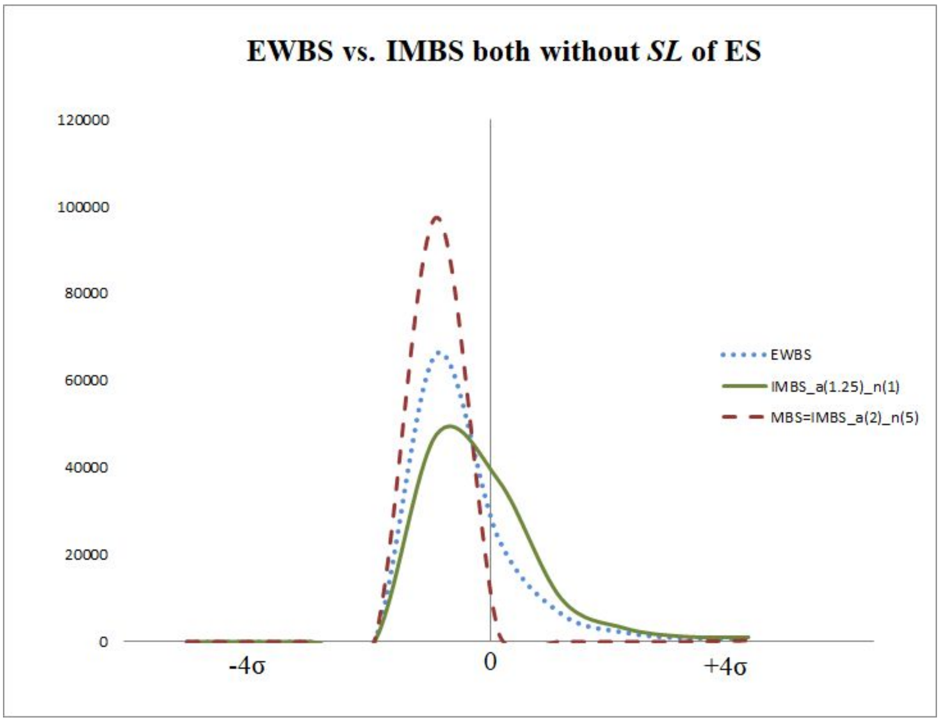

Figure 5: EWBS and IMBS both without SL of ES.

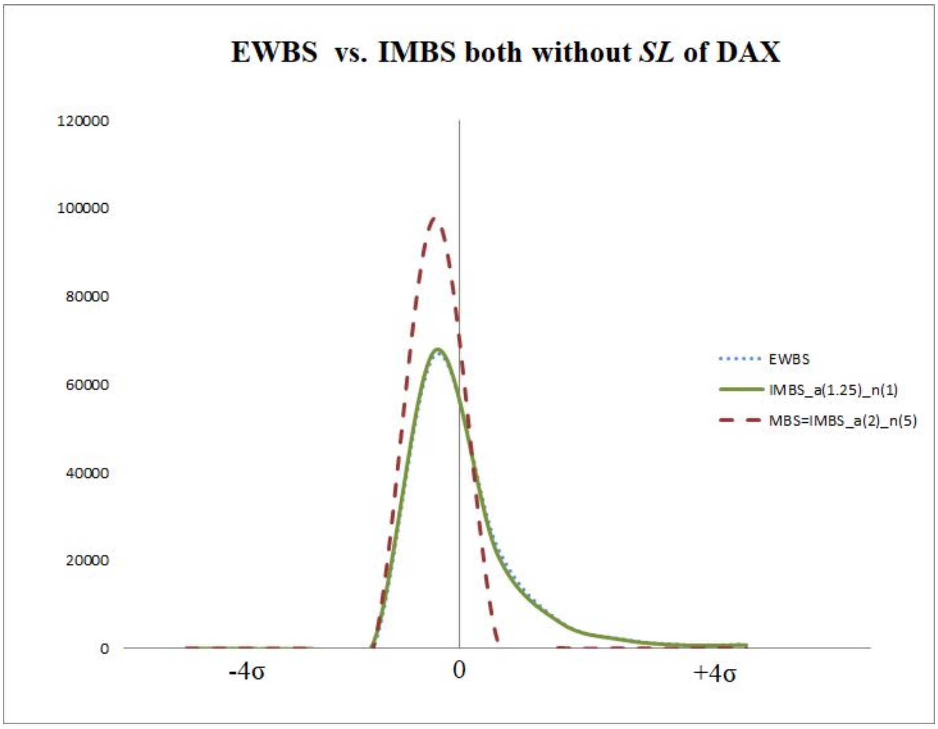

Figure 6: EWBS and IMBS both without SL of DAX.

Table 7: Returns of IMBS with SL of TX.

$\boldsymbol{SL_{TX}}$	$\boldsymbol{a}$	$\boldsymbol{n}$	**Mean Return**	**Mean Broken Rate**	**Standard Deviation ($\boldsymbol{\sigma}$)**	**t-statistics ($\mathbf{H_1}$: $\boldsymbol{\mu_{EWBS,SL} < \mu_{IMBS,SL}}$)**	**t-statistics ($\mathbf{H_1}$: $\boldsymbol{\mu_{EWBS,SL} > \mu_{(IMBS,SL)}}$)**
1θ	1.25	1	5.87	0.00%	3.88	-145.63^{***}	
	1.25	3	9.48	0.00%	5.79	-125.87^{***}	
	1.25	5	12.63	0.00%	9.45	-110.32^{***}	
	1.5	1	7.84	0.00%	12.90	-131.67^{***}	
	1.5	3	25.55	0.00%	7.36	-83.89^{***}	
	1.5	5	62.75	0.00%	30.20	-46.67^{***}	
	1.75	1	10.76	0.00%	171.82	-111.60^{***}	
	1.75	3	81.57	0.00%	1479.76	-47.35^{***}	
	1.75	5	469.06	0.00%	11.26	-14.94^{***}	
	2	1	14.01	0.00%	133.99	-109.96^{***}	
	2	3	310.24	0.00%	3137.95	-20.95^{***}	
	2	5	1429.82	0.00%	8191.46	-17.45^{***}	

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

4.4 IMBS with Stop Loss

Consider the one-tailed two sample t-test with the null hypothesis $\mathrm{H}_0 : \mu_{IMBS,SL} = \mu_{EWBS,SL}$ against the alternative hypothesis $\mathrm{H}_1 : \mu_{EWBS,SL} < \mu_{IMBS,SL}$ except for those cases which t-statistics in Table 6 to Table 8 are close to zero or even positive, where $\mu_{IMBS,SL}$ denotes the expected return of IMBS with SL, and the alternative hypothesis for those excluded cases: $\mathrm{H}_1 : \mu_{IMBS,SL} < \mu_{EWBS,SL}$. The result of each of three instruments conducted with 4,800,000 rounds of random entry tests by setting IMBS with four different levels of SL, four levels of betting multiples a and three levels of times limit n from 2001 to 2020 could be found in Appendix 1. The results of TX are all extremely significant, but are mixed in the ES and DAX. Overall, when we set stop loss rate by 0.75θ and 1θ, the results of IMBS with SL will have significant improvement overall. Tables 7 to 9 show the results by setting $SL = 1\theta$ with various parameters in each instrument.

From Table 7 we can see that the IMBS has significant improvement in TX, and there is an interesting phenomenon that MBS in TX (as IMBS by setting $a = 2$, $n = 5$) happens to have the best result. Except normal MBS function, the IMBS with setting $a = 1.75$, $n = 5$ has the best result. It seems that limiting the leverage at 20 times playing a part of this result.

Table 8: Returns of IMBS with SL of ES.

SL_{ES}	a	n	Mean Return	Mean Broken Rate	Standard Deviation (σ)	t-statistics ($H_1 : \mu_{EWBS,SL} < \mu_{IMBS,SL}$)	t-statistics ($H_1 : \mu_{EWBS,SL} > \mu_{IMBS,SL}$)
1θ	1.25	1	-0.25	0.00%	0.43	-32.39^{***}	
	1.25	3	-0.31	0.00%	0.47	-16.71^{***}	
	1.25	5	-0.32	0.00%	0.53	-11.71^{***}	
	1.5	1	-0.29	0.00%	0.61	-22.94^{***}	
	1.5	3	-0.42	0.00%	0.52		3.79^{***}
	1.5	5	-0.48	0.00%	0.75		5.33^{***}
	1.75	1	-0.32	0.00%	1.22	-14.78^{***}	
	1.75	3	-0.56	0.00%	1.50		13.88^{***}
	1.75	5	-0.68	0.51%	0.65		7.29^{***}
	2	1	-0.34	0.00%	1.55	-8.39^{***}	
	2	3	-0.74	0.00%	3.86		23.14^{***}
	2	5	-0.76	4.84%	5.00		7.32^{***}

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

Table 9: Returns of IMBS with SL of DAX.

SL_{DAX}	a	n	Mean Return	Mean Broken Rate	Standard Deviation (σ)	t-statistics ($H_1 : \mu_{EWBS,SL} < \mu_{IMBS,SL}$)	t-statistics ($H_1 : \mu_{EWBS,SL} > \mu_{IMBS,SL}$)
1θ	1.25	1	0.69	0.00%	0.94	-41.18^{***}	
	1.25	3	0.84	0.00%	1.22	-40.46^{***}	
	1.25	5	0.89	0.00%	1.62	-37.18^{***}	
	1.5	1	0.89	0.00%	2.06	-47.90^{***}	
	1.5	3	1.17	0.00%	1.31	-33.56^{***}	
	1.5	5	1.38	0.00%	2.59	-15.79^{***}	
	1.75	1	1.11	0.00%	7.30	-49.87^{***}	
	1.75	3	1.48	0.00%	12.55	-16.14^{***}	
	1.75	5	1.09	0.01%	1.58	-4.10^{***}	
	2	1	1.31	0.00%	6.87	-48.53^{***}	
	2	3	1.63	0.00%	19.31	-10.57^{***}	
	2	5	-0.03	0.20%	12.34	2.68	2.68^{**}

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

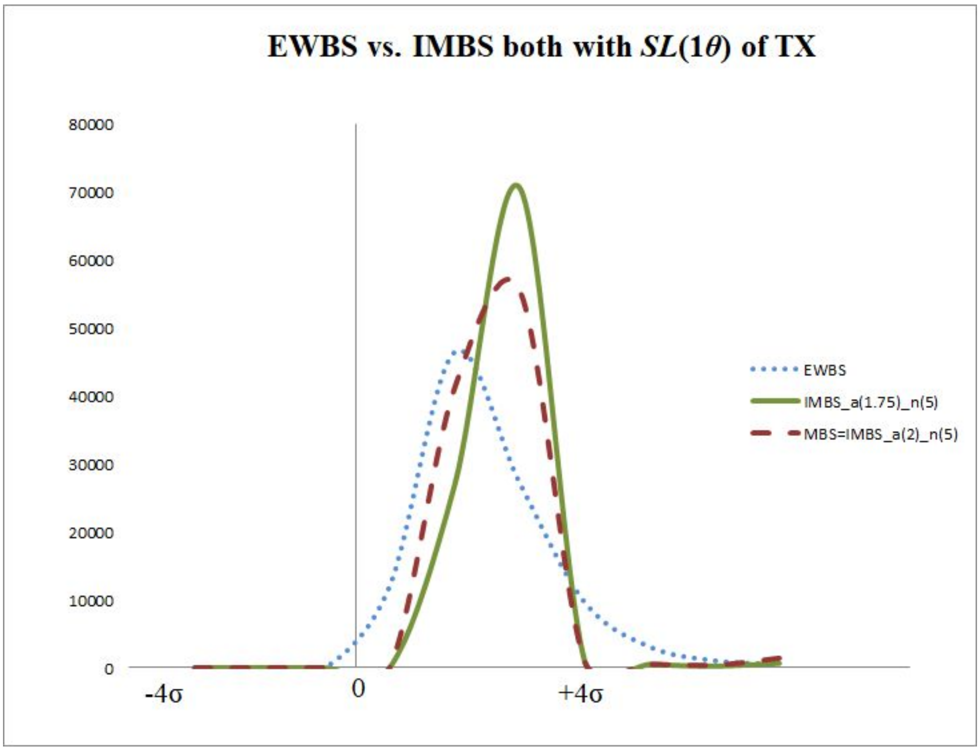

Figure 7: EWBS and IMBS both with $SL(1\theta)$ of TX.

In ES, the MBS not surprisingly causes the worst result and has 4.84% of tests bankrupted. Most of IMBS results are better than EWBS. The IMBS with setting $a = 1.25$, $n = 1$ has the best result. And the results show that the multiplier n seems to have no apparent effect in ES.

The MBS still has the worst result in DAX as shown in Table 9. It is worth noting that there is no leverage limitation by original MBS, but we can see here with total leverage limitation at 8 ($a = 2$,$n = 3$) we will have the best return in DAX. Except setting $a = 2$, the IMBS with setting $a = 1.75$, $n = 3$ will have the best result and it is almost the same as $a = 2$, $n = 3$. It tells us again that total leverage limitation seems to be the point whatever a or n is.

In Figure 7, we can see that compared with EWBS and MBS, IMBS has absolute advantage, and even MBS under this setting is happened to be profitable in TX, IMBS still has an extraordinary improvement.

In Figure 8, the optimal parameter distribution curve of the IMBS almost overlaps with that of the EWBS, but still is much more improved for the MBS.

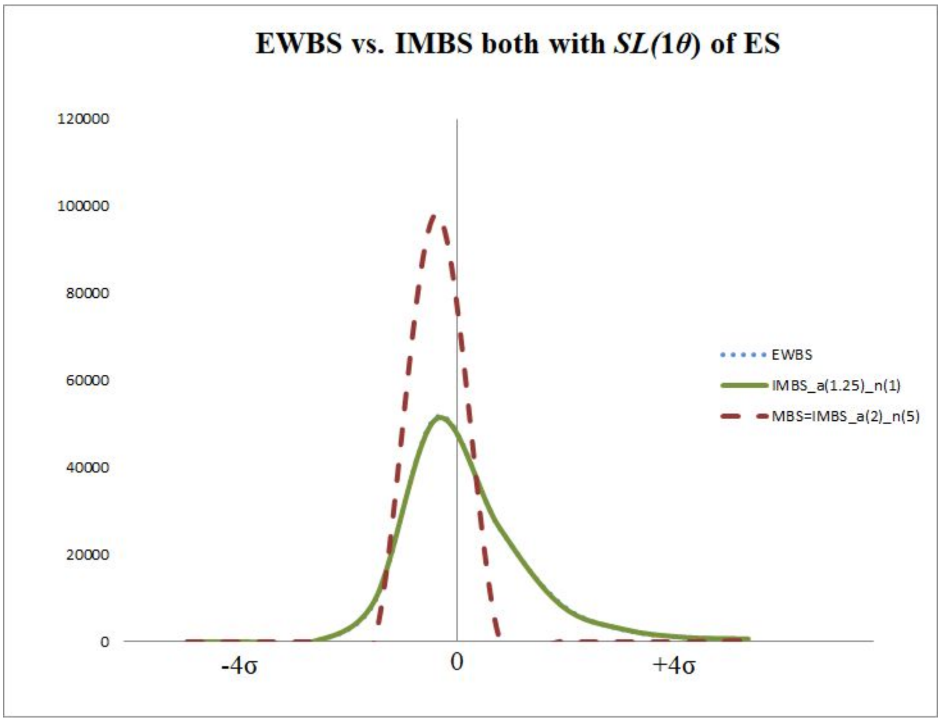

Figure 8: EWBS and IMBS both with $SL(1\theta)$ of ES.

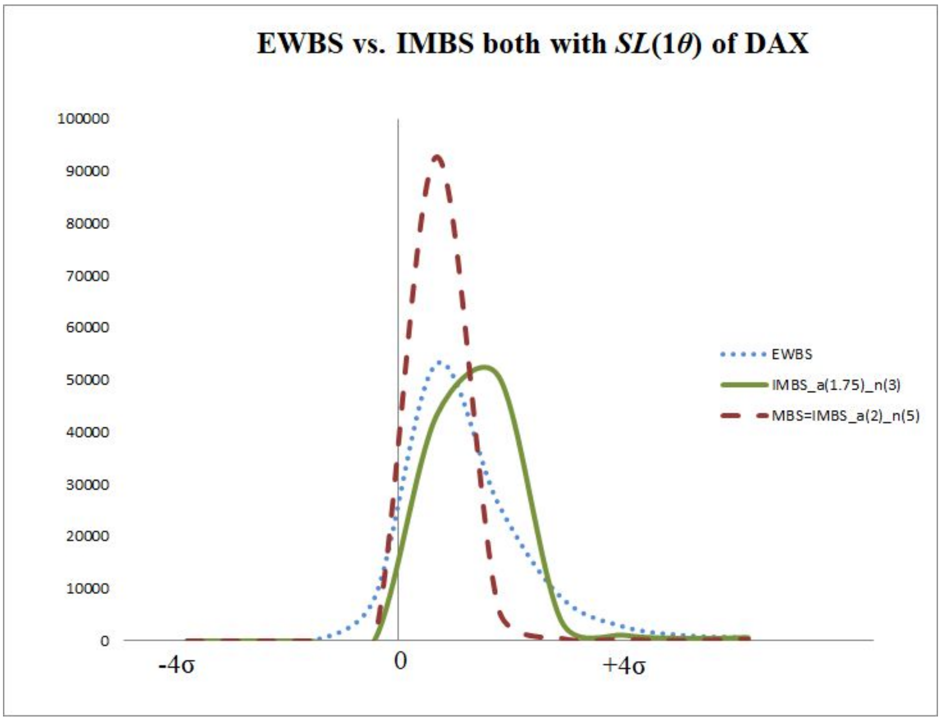

Figure 9: EWBS and IMBS both with $SL(1\theta)$ of DAX.

In Figure 9, the performance of IMBS is not that dramatic as in TX, but IMBS still has obvious advantage compared with EWBS. The IMBS also has significant improvement over MBS.

5. Conclusions

EWBS with stop loss mechanism has better results than without stop loss, and it shows that random entry betting with stop loss control can make the stochastic game a profitable trading especially in TX and DAX.

The IMBS with appropriate settings on stop loss rate, betting multiples, and amount limitation will have significant improvement than EWBS under both cases of having SL or not, and the traditional MBS causes bankruptcy in many tests which is also in line with theoretical reasoning.

This research shows that if we can measure maximum leverage and stop loss amount, we may apply IMBS mechanism to gain a better performance. The IMBS can be a profitable fund management for intraday trading.

Appendix 1.

Table 10: Returns of IMBS with $\boldsymbol{SL}$ of TX.

$\boldsymbol{SL}$	$\boldsymbol{a}$	$\boldsymbol{n}$	**Mean Return**	**Standard Deviation ($\boldsymbol{\sigma}$)**	**Mean Broken Rate**	**t-statistics ($\mathbf{H_1}: \boldsymbol{\mu_{EWBS,SL} < \mu_{IMBS,SL}}$)**	**t-statistics ($\mathbf{H_1}: \boldsymbol{\mu_{EWBS,SL} > \mu_{IMBS,SL}}$)**
1θ	1.25	1	5.87	3.88	0.00%	-145.63^{***}	
	1.25	3	9.48	5.79	0.00%	-125.87^{***}	
	1.25	5	12.63	9.45	0.00%	-110.32^{***}	
	1.5	1	7.84	12.90	0.00%	-131.67^{***}	
	1.5	3	25.55	7.36	0.00%	-83.89^{***}	
	1.5	5	62.75	30.20	0.00%	-46.67^{***}	
	1.75	1	10.76	171.82	0.00%	-111.60^{***}	
	1.75	3	81.57	1479.76	0.00%	-47.35^{***}	
	1.75	5	469.06	11.26	0.00%	-14.94^{***}	
	2	1	14.01	133.99	0.00%	-106.96^{***}	
	2	3	310.24	3137.95	0.00%	-20.95^{***}	
	2	5	1429.82	8191.46	0.00%	-17.45^{***}	
0.75θ	1.25	1	7.04		0.00%	-169.90^{***}	
	1.25	3	13.69	6.61	0.00%	-143.51^{***}	
	1.25	5	20.77	10.26	0.00%	-122.88^{***}	
	1.5	1	10.15	16.61	0.00%	-151.96^{***}	
	1.5	3	47.78	9.46	0.00%	-87.99^{***}	
	1.5	5	189.23	54.17	0.00%	-46.36^{***}	
	1.75	1	14.21	490.07	0.00%	-137.29^{***}	
	1.75	3	228.03	4524.79	0.00%	46.51^{***}	
	1.75	5	2633.46	16.81	0.00%	-26.83^{***}	
	2	1	19.97	407.91	0.00%	-119.53^{***}	
	2	3	1270.98	9814.32	0.00%	-28.09^{***}	
	2	5	6275.12	18669.49	0.00%	-33.61^{***}	

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

SL	a	n	Mean Return	Standard Deviation (σ)	Mean Broken Rate	t-statistics ($H_1 : \mu_{EWBS,SL} < \mu_{IMBS,SL}$)	t-statistics ($H_1 : \mu_{EWBS,SL} > \mu_{IMBS,SL}$)
0.5θ	1.25	1	4.53	2.40	0.00%	-184.50^{***}	
	1.25	3	8.86	3.78	0.00%	-125.81^{***}	
	1.25	5	15.49	5.60	0.00%	-125.91^{***}	
	1.5	1	6.31	8.47	0.00%	-163.91^{***}	
	1.5	3	30.90	5.73	0.00%	-98.94^{***}	
	1.5	5	161.66	31.12	0.00%	-43.85^{***}	
	1.75	1	8.57	255.6	0.00%	-151.07	
	1.75	3	137.75	2877.6	0.00%	-53.85^{***}	
	1.75	5	3095.21	12.22	0.00%	-27.12^{***}	
	2	1	11.41	368.46	0.00%	-133.49^{***}	
	2	3	754.72	11411.82	0.00%	-26.22^{***}	
	2	5	7566.10	20003.48	0.00%	-37.82^{***}	
0.25θ	1.25	1	1.67	0.88	0.00%	-191.22^{***}	
	1.25	3	2.95	1.29	0.00%	-159.22^{***}	
	1.25	5	4.70	1.81	0.00%	-122.73^{***}	
	1.5	1	2.23	2.49	0.00%	-173.92	
	1.5	3	7.54	1.86	0.00%	-104.92^{***}	
	1.5	5	25.05	7.2	0.00%	-39.66^{***}	
	1.75	1	2.89	35.42	0.00%	-160.03^{***}	
	1.75	3	21.13	181.7	0.00%	-59.69^{***}	
	1.75	5	190.93	3.84	0.00%	-8.52^{***}	
	2	1	3.69	63.17	0.00%	-148.34^{***}	
	2	3	60.28	2240.30	0.00%	-33.18^{***}	
	2	5	765.12	6317.87	0.00%	-12.11^{***}	

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

Table 11: Returns of IMBS with $\boldsymbol{SL}$ of ES.

$\boldsymbol{SL}$	$\boldsymbol{a}$	$\boldsymbol{n}$	**Mean Return**	**Mean Broken Rate**	**Standard Deviation (σ)**	**t-statistics ($\mathrm{H}_1 : \mu_{EWBS,SL} < \mu_{IMBS,SL}$)**	**t-statistics ($\mathrm{H}_1 : \mu_{EWBS,SL} > \mu_{IMBS,SL}$)**
1θ	1.25	1	-0.25	0.00%	0.43	-32.29^{***}	
	1.25	3	-0.31	0.00%	0.47	-16.71^{***}	
	1.25	5	-0.32	0.00%	0.53	-11.71^{***}	
	1.5	1	-0.29	0.00%	0.61	-22.94^{***}	
	1.5	3	-0.42	0.00%	0.52		3.79^{***}
	1.5	5	-0.48	0.00%	0.75		5.33^{***}
	1.75	1	-0.32	0.00%	1.22	-14.78^{***}	
	1.75	3	-0.56	0.00%	1.50		13.88^{***}
	1.75	5	-0.68	0.51%	0.65		7.29^{***}
	2	1	-0.34	0.00%	1.55	-8.39^{***}	
	2	3	-0.74	0.00%	3.86		23.14^{***}
	2	5	-0.76	4.84%	5.00		7.32^{***}
0.75θ	1.25	1	-0.30	0.00%	0.35	-27.81^{***}	
	1.25	3	-0.33	0.00%	0.40	-15.92^{***}	
	1.25	5	-0.35	0.00%	0.45	-8.36^{***}	
	1.5	1	-0.33	0.00%	0.50	-18.15^{***}	
	1.5	3	-0.44	0.00%	0.46		5.61^{***}
	1.5	5	-0.53	0.00%	0.73		8.58^{***}
	1.75	1	-0.37	0.00%	1.08	-7.32^{***}	
	1.75	3	-0.57	0.00%	1.21		15.66^{***}
	1.75	5	-0.72	0.64%	0.62		8.11^{***}
	2	1	-0.39	0.00%	1.56	-1.21	-1.21
	2	3	-0.75	0.00%	3.99		29.26^{***}
	2	5	-0.87	5.19%	3.10		15.24^{***}

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

SL	a	n	Mean Return	Mean Broken Rate	Standard Deviation (σ)	t-statistics ($H_1 : \mu_{EWBS,SL} < \mu_{IMBS,SL}$)	t-statistics ($H_1 : \mu_{EWBS,SL} > \mu_{IMBS,SL}$)
0.5θ	1.25	1	-0.34	0.00%	0.29	-33.77^{***}	
	1.25	3	-0.42	0.00%	0.32	-4.55^{***}	
	1.25	5	-0.48	0.00%	0.35		9.05^{***}
	1.5	1	-0.38	0.00%	0.37	-15.81^{***}	
	1.5	3	-0.57	0.00%	0.35		27.75^{***}
	1.5	5	-0.76	0.00%	0.48		49.82^{***}
	1.75	1	-0.42	0.00%	0.55	-4.41^{***}	
	1.75	3	-0.74	0.00%	0.64		56.13^{***}
	1.75	5	-0.95	0.46%	0.44		45.88^{***}
	2	1	-0.46	0.00%	0.64		7.17^{***}
	2	3	-0.88	0.00%	1.11		69.78^{***}
	2	5	-0.98	3.99%	0.68		79.90^{***}
0.25θ	1.25	1	-0.47	0.00%	0.16		46.27^{***}
	1.25	3	-0.57	0.00%	0.17		88.78^{***}
	1.25	5	-0.65	0.00%	0.18		112.87^{***}
	1.5	1	-0.52	0.00%	0.19		70.17^{***}
	1.5	3	-0.73	0.00%	0.19		157.32^{***}
	1.5	5	-0.91	0.00%	0.21		250.16^{***}
	1.75	1	-0.57	0.00%	0.20		92.39^{***}
	1.75	3	-0.87	0.00%	0.13		239.22^{***}
	1.75	5	-1.00	1.14%	0.23		1513.40^{***}
	2	1	-0.61	0.00%	0.20		110.31^{***}
	2	3	-0.96	0.00%	0.02		432.02^{***}
	2	5	-1.00	7.49%	0.26		232.68^{***}

Note. $^{***} : p < 0.001$, $^{**} : p < 0.01$, $^{*} : p < 0.05$.

Table 12: Returns of IMBS with $\boldsymbol{SL}$ of DAX.

$\boldsymbol{SL}$	$\boldsymbol{a}$	$\boldsymbol{n}$	**Mean Return**	**Mean Broken Rate**	**Standard Deviation (σ)**	**t-statistics ($\mathbf{H_1}: \mu_{EWBS,SL} < \mu_{IMBS,SL}$)**	**t-statistics ($\mathbf{H_1}: \mu_{EWBS,SL} > \mu_{IMBS,SL}$)**
1θ	1.25	1	0.69	0.00%	0.94	-41.18^{***}	
	1.25	3	0.84	0.00%	1.22	-40.46^{***}	
	1.25	5	0.89	0.00%	1.62	-37.18^{***}	
	1.5	1	0.89	0.00%	2.06	-47.90^{***}	
	1.5	3	1.17	0.00%	1.31	-33.56^{***}	
	1.5	5	1.38	0.00%	2.59	-15.79^{***}	
	1.75	1	1.11	0.00%	7.30	-49.87^{***}	
	1.75	3	1.48	0.00%	12.55	-16.14^{***}	
	1.75	5	1.09	0.01%	1.58	-4.10^{***}	
	2	1	1.31	0.00%	6.87	-48.53^{***}	
	2	3	1.63	0.00%	19.31	10.57^{***}	
	2	5	-0.03	0.20%	12.34		2.68^{***}
0.75θ	1.25	1	0.36	0.00%	0.67	-26.91^{***}	
	1.25	3	0.31	0.00%	0.82	-15.94^{***}	
	1.25	5	0.29	0.00%	0.99	-10.51^{***}	
	1.5	1	0.43	0.00%	1.22	-30.25^{***}	
	1.5	3	0.32	0.00%	0.81	-9.56^{***}	
	1.5	5	0.06	0.00%	1.41		3.98^{***}
	1.75	1	0.52	0.00%	2.18	-33.93^{***}	
	1.75	3	0.12	0.00%	3.63		2.77^{**}
	1.75	5	-0.63	0.05%	1.04		25.23^{***}
	2	1	0.61	0.00%	3.04	-35.13^{***}	
	2	3	-0.15	0.00%	3.20		9.08^{***}
	2	5	-0.74	0.27%	14.19		6.45^{***}

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

SL	a	n	Mean Return	Mean Broken Rate	Standard Deviation (σ)	t-statistics ($H_1 : \mu_{EWBS,SL} < \mu_{IMBS,SL}$)	t-statistics ($H_1 : \mu_{EWBS,SL} > \mu_{IMBS,SL}$)
0.5θ	1.25	1	0.11	0.00%	0.43	0.31	0.31
	1.25	3	0.06	0.00%	0.51		9.71^{***}
	1.25	5	-0.06	0.00%	0.60		25.37^{***}
	1.5	1	0.12	0.00%	0.72	-2.01^{*}	
	1.5	3	-0.07	0.00%	0.54	21.11	21.11^{***}
	1.5	5	-0.48	0.00%	0.82	57.88	57.88^{***}
	1.75	1	0.13	0.00%	1.23	-3.37^{***}	
	1.75	3	-0.27	0.00%	1.71		31.24^{***}
	1.75	5	-0.93	0.05%	0.65		181.18^{***}
	2	1	0.16	0.00%	1.02	-6.79^{***}	
	2	3	-0.54	0.00%	0.57		37.88^{***}
	2	5	-0.97	0.34%	0.87		122.89^{***}
0.25θ	1.25	1	-0.15	0.00%	0.24		105.98^{***}
	1.25	3	-0.28	0.00%	0.27		133.18^{***}
	1.25	5	-0.44	0.00%	0.31		166.28^{***}
	1.5	1	-0.17	0.00%	0.35		100.98^{***}
	1.5	3	-0.49	0.00%	0.28		168.61^{***}
	1.5	5	-0.83	0.00%	0.35		321.06^{***}
	1.75	1	-0.20	0.00%	0.35		98.81^{***}
	1.75	3	-0.71	0.00%	0.34		232.22^{***}
	1.75	5	-0.99	0.04%	0.32		1315.80^{***}
	2	1	-0.22	0.00%	0.29		94.49^{***}
	2	3	-0.88	0.00%	0.04		287.59^{***}
	2	5	-1.00	0.52%	0.01		1458.70^{***}

Note. $^{***}: p < 0.001$, $^{**}: p < 0.01$, $^{*}: p < 0.05$.

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改良式馬丁格爾投注法應用於指數期貨日內交易

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摘 要

馬丁格爾投注法起源於輪盤賭博，概念是如果本次賭輸則下次投注翻倍直到某次贏了為止才回復原始下注金額。理論上在公平的賭局下，這種方式一定能贏，但在真實情況下，受限於資金數量、非公平賭局等因素，馬丁格爾投注法並不能成功。本研究中我們提出了一種創新的資金管理方法 – 改良式馬丁格爾投注法 (IMBS)，是針對傳統馬丁格爾投注法加以改變並加上停損機制。將其運用於美國、德國、台灣三種主要指數期貨日內交易的測試結果顯示，改良式馬丁格爾投注法相較於沒有資金管理的交易或採用傳統馬丁格爾投注法的交易，在績效上有顯著的提升，因此本文顯示改良式馬丁格爾投注法在指數期貨日內交易上具有極高的應用價值。

關鍵詞: 馬丁格爾投注法、股價指數期貨、日內交易、改良式馬丁格爾投注法。

JEL classification: G13.

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